Quarterly Report

Period: January 1 - March 31

Remote Sensing Group (RSG), Optical Sciences Center at the University of Arizona
Principal Investigator: P. Slater

Contract Number: NAS5-31717

Report compiled by: K. Thome

Summary:
Work by members of the RSG during the past quarter consisted of Science Team support activities including the submission of several calibration papers, attendance at meetings related to MODIS, SeaWiFS, and MISR, work on the atmospheric correction of ASTER data, and assisting in a stray light study for MODIS. We continued improvements to our calibration facilities and blacklab including characterization of our Optronic monochromator, field radiometer FOV studies, receipt of a clean bench, and work to automate our blacklab measurements. Field work activities were continued with trip planning to White Sands and Lake Tahoe in April and work on developing new and improving existing equipment for future work.

Task Progress:
Rob Kingston joined the group in January as a software engineer and programmer. He will help write software controlling equipment in the laboratory for spectral measurements and for reflectance and FOV measurements in the blacklab. He will also help with network and computer system administration. A visiting French student, Michael Sicard joined the group in February. He will work with the group for 5 months assisting K. Thome with optical depth measurements in the SWIR using both our ASD spectroradiometer and the RSG developed SWIR spectroradiometer.

P. Slater and S. Biggar finished the draft of a paper titled "Suggestions for radiometric calibration coefficient generation" and sent it to 35 calibration scientists around the world for comments. It was also submitted to the Journal of Atmospheric and Ocean Technology for inclusion in a special calibration issue. Slater and K. Thome completed the first draft of a paper titled "Radiometric calibration of ASTER data" and submitted it to the Journal of Remote Sensing of Japan. The paper is coauthored by K. Arai H. Fujisada, H. Kieffer, A. Ono, F. Sakuma, F. Palluconi, and Y. Yamaguchi. On 2 February, Slater met with B. Guenther and other members of MCST to discuss scan-mirror reflectance change with angle and other concerns. Slater also attended the MODIS Technical Team meeting. The following day he attended an ASTER/Landsat meeting and gave a presentation on vicarious calibration. From 22-24 February he attended the Multisensor Ocean Color Workshop in Miami and participated in the Calibration and Characterization Workshop. On 28 February he discussed the

results of the Workshop with C. McClain and B. Barnes and provided them three pages of comments and suggestions regarding calibration activities for national and international ocean color sensors. He had further meetings with MCST personnel discussing MTF measurements and stray light. The following day he attended the SWAMP meeting.

P. Spyak travelled to SBRC in January to observe near-field scatter measurements for MODIS. Problems with software, electronics, offsets and gains, and charge subtraction prevented him from observing the tests. C. Thompson (SBRC) described test design and procedure, and Spyak toured the high bay and test setup. G. Godden (MCST) and Spyak pointed out that overfilling the ScMA mirror may lead to significant stray light problems in the measurements and that the tests yield little track direction information. They suggested a test to provide this information. Spyak reviewed BRDF data with T. Kampe and Godden and the aft optic's BTDF measurements with Godden. Spyak analyzed the MODIS aft optics scatter data for wavelengths of 0.63, 3.39, and 10.6 micrometers. He reviewed the results with Godden and went to Breault Research Organization, Inc. (BRO) for a teleconference call with Godden, R. Breault (BRO), and D. Milsom (BRO). Spyak reviewed and commented on Godden's paper entitled "Notes regarding the scan mirror reflectivity measurement requirements and the proposed SBRC scan mirror reflectivity measurement plan," report number MCST/PAI 95001-A. He analyzed MODIS's scan mirror BRDF data and discussed results of analysis with Godden and Kampe while at SBRC and also in a teleconference with Godden, Kampe, J. Young (SBRC), and Breault and Milsom. Based on these discussions, an agreement was reached on the region of valid data, and how to extrapolate these data to smaller angles. Spyak is concerned that the scatterometers may not have the needed repeatability to make such small-angle scatter measurements and that the illumination spot size may not be large enough to average over a reasonable number of surface spatial frequencies. Kampe is investigating this. As requested by Godden, Spyak reviewed and analyzed BRO's Harvey-Shack fits to the MODIS scatter data. All of the fits except for the scan mirror fit were very good. The scan mirror fit, however, badly overestimated the small-angle scatter by roughly a factor of ten for angles less than 0.5 degrees, and significantly overestimated the scatter out to about one degree. Also, the CdTe data were too high by as much as a factor of seven between 0.5 and 1.0 degrees. As a result of scan mirror data error, BRO has redone some of the computations.

Thome attended the AVIRIS and TIMS Conferences at JPL January 23-24 and January 26. On January 25, he met with B. Eng of JPL to discuss the database requirements for the atmospheric correction and with G. Geller, J. Martonchik, and F. Palluconi (all of JPL) to discuss MISR aerosol products. On January 27, Thome met with J. Conel, M. Helmlinger, S. Hook, A. Kahle, A. Morrison, Palluconi and J. Schieldge to discuss a collaborative TIR calibration campaign at Lake Tahoe in April. Spyak performed some quick

analyses and studies of the contamination requirements for ASTER and sent comments to F. Palluconi of JPL. Biggar attended the MISR Cal peer review 27-28 March at JPL and sent comments to S. Reber. Biggar travelled to Ann Arbor, Michigan January 25-28 to make measurements of the calibration units for HYDICE. He also assisted the HYDICE ground crew to set up surface validation targets for the sensor. Biggar and Slater attended a HYDICE meeting in Tempe on 15 March where Biggar gave a short talk on the measurements made at ERIM in January.

Biggar modified the data collection software for the silicon transfer radiometer to speed up the collection cycle using the HP voltmeter instead of the Fluke data logger. He tested the stability of the 6" SIS used as an "aliveness" check when traveling with the radiometer. A new mount for accurately aligning the radiometer and SIS was designed and built by C. Burkhart. Biggar and S. Recker shipped the radiometer to Japan and Biggar travelled to Yokohama, Japan February 17-25 to participate in an ASTER/OCTS cross-calibration experiment. The goals of the experiment were to measure NEC's spherical-integrating sources (SIS) for ASTER and the OCTS using the VNIR transfer radiometer. Other participants in the experiment included NASA EGOS calibration scientist J. Butler, J. Cooper, a NASA calibration technician, C. Johnson of NIST, F. Sakuma from NRLM, and various NEC people and observers from JAROS and NASDA. They measured the ASTER (1-meter diameter) SIS on Tuesday and Wednesday and the OCTS (2-meter diameter) SIS on Thursday and Friday. Preliminary study of the measurements indicate NEC's calibrations for the SISs are in general lower than what is indicated by radiometer measurements made by Biggar, NIST, and NRLM with the largest difference reported by NRLM. The GSFC Optronic spectrometer setup has some stray room light problems which made early examination of their measurements problematic. After returning from Japan, Biggar used the radiometer to view our NIST standard lamp in irradiance mode. B. Nelson has started assembly of the new version of the silicon radiometer as parts have finally arrived. The electronics for this version are more robust mechanically as is the construction of the detector assembly. The circuit designs and optical details are identical to the "prototype".

Spyak researched the use of bolometers for the detectors for the TIR transfer radiometer by visiting Infrared Laboratories to discuss applications and requirements. He determined that a bolometer is the correct detector for this application, and that he and Infrared Laboratories would work together on the design. Biggar, Slater, and Spyak have since decided to cancel this effort because it cannot be used directly to calibrate MODIS and ASTER sources due to vacuum chamber requirements and budgetary constraints. Instead, J. Walker and Spyak will design and build a TIR field radiometer. We hope to eventually build a nearly identical copy of this radiometer for transfer calibration of field blackbodies. Walker is reading applicable literature, beginning some initial calculations, and defining the instrument

and project specifications. He also began determining a schedule for the project and investigating satellite sensor requirements for the radiometer to bracket the instruments dynamic range and required sensitivity.

Spyak decided to design the SWIR transfer radiometer around an InSb detector based on discussions of detector and electronics with various vendors, D. Joyce of NOAO at Kitt Peak., and E. Dereniak of the University of Arizona Optical Sciences Center Linearity, repeatability, and stability will all be limited by electronics, not the detector itself. Spyak is identifying these limitations. Spyak worked on the baffle design, customization requirements for the detector/dewar/electronics package, and the bandpass filter selection. He looked into noise problems of 3 - 6.3 micrometer signal detection. He developed specifications for the cold filter, dewar window and bandpass filters, and analyzed the thermal rejection requirements. He discussed his designs with filter vendors analyzed the detector mask scatter effects and tolerancing baffle design. Spyak developed schematic drawings of the radiometer.

Work in the blacklab continued with the receipt of a filter wheel motor, lamp alignment jig and kinematic mount. Burkhart designed and constructed mounts for the new optical breadboard and designed lamp mounting fixtures. Spyak returned the multimeter and shunt for calibration. LaMarr and Spyak measured the Che radiometer FOV, and LaMarr estimates the error in blacklab panel calibrations due to the FOV to be less than 1%. LaMarr designed and constructed a mount for our Barnes MMR to measure its FOV and he and R. Parada measured the MMR FOV for one of the SWIR channels. The results of these measurements show the radiometer will out-of-field problems due to stray light when used for blacklab panel calibrations. LaMarr estimates that the error in a reflectance panel calibration due to the out-of-field problems to be in the 3-5% range. Spyak examined crosshair mirror reticles for system alignment and discussed blacklab modifications with B. Crowther which will be necessary to measure the FOV of the diffuse-to-global meter. Spyak designed a baffle system to surround the lamp and eliminate direct views of the lamp and submitted the plans to Burkhart. Burkhart completed the fabrication of the new Che mount, Che alignment fixtures, lamp stage fixturing, and lamp platform. J. LaMarr realigned the blacklab instrumentation and performed measurements to verify its repeatability with previous measurements. Biggar installed and tested a GPIB interface in the new blacklab PC. LaMarr installed Windows NT on this system and checked that the ZEMAX-EE lens design code runs under NT. Biggar installed LabView for Sun Solaris on a cobra (a Sun S20). This will be used to program the lamp, shutter, radiometer, and goniometer control software in the blacklab using an ethernet-GPIB controller. Biggar and Kingston worked on porting blacklab software to the laboratory PC system but have encountered problems with the GPIB. They began work to allow the HP3245A to control the lamp output via the new blacklab computer.

Spyak received the clean bench for the calibration laboratory. Spyak identified and ordered clean bench apparel. B. Nelson attached the power cables to the bench. Nelson and Spyak ordered, received, and assembled a cabinet to house the clean bench apparel and accessories and ordered and received a clean bench chair. We received a tip-tilt stage, a hemispherical reflectance attachment for the Optronic monochromator, chopper blades for the previously received chopper assembly and motor, lock-in amplifier board, blackbody source. LaMarr ordered a temperature/humidity sensor and assembled and tested the water deionizer. M. Brownlee, Spyak, and Thome discussed methods for determining the nonuniformity of our 40" SIS and CCD non-uniformity correction.

Optronic returned our repaired monochromator in January. While repairing the system, Optronic found a power drop throughout the unit whenever there was a change in filter or grating. This would cause such things as moving the chopper when it should not move, and improper filter wheel positioning. There were numerous repairs: [a] controller internal software upgraded from V. 3.20 to V. 4.0, [b] monochromator stepper motor controller pcb software upgraded from V. 3.20 to V. 3.30, [c] monochromator chopper controller pcb software upgraded from V. 3.10 to V. 3.30 (partially based on Biggar's suggestion to continuously monitor the chopper position when in DC mode), [d] additional grounding wires added to the control cable, [e] separate +5V power supply added to the stepper motor control pcb, [f] new software, V. 4.10. LaMarr loaded the new software, and set the unit up and checked it. The filter wheel for the repaired system did not operate, which Optronic replaced and we installed. LaMarr and Spyak spectrally calibrated the system to within 0.05% of wavelength specification using the mercury and krypton sources. The agreement in transmittance of a filter measured before and after the repairs is better than 1%, except in the cutoff and cuton regions of the filter where spectral accuracy and precision play a significant role. LaMarr and Spyak determined the Optronic monochromator has a significant drift in its signal output. After further experimentation, they determined the drift is due to mechanical stresses induced by the thermal expansion and contraction during use. LaMarr and Spyak have attempted to eliminate these stresses, and the system now appears to be stable to about 0.5%. LaMarr also checked spectral errors due to inserting and removing the slits and found these errors to be about 0.02%. In preparation for his Japan trip, Biggar used the system to measure the spectral filter transmittance for each band of the VNIR transfer radiometer. He and LaMarr measured all of the filters with both narrow (about 0.25 nm FWHM resolution) and wider (about 1 nm FWHM resolution) slits.

Brownlee completed the carrying cases for the BRDF meter. She completed designs for panel holders for the instrument's Spectralon panels and these were made by the OSC machine shop and have been tested by Brownlee in the blacklab. She completed design of and partially constructed the storage and transportation

units for the panels and worked on the design of the filter wheel which is currently being machined by Burkhart. Biggar and Brownlee modified blacklab control software to allow reflectance panels to be rotated from vertical. Brownlee continued developing IDL data display software and examining the effect of grazing angle, surface, and specular reflectance on the predicted radiance at the top of the atmosphere. Burkhart worked on the BRDF camera filter holder.

Biggar and B. Crowther evaluated various servo and stepper motor solutions for the diffuse-to-global meter and the radiometer filter wheel. This is still under study and more systems are being evaluated. The desire is for a small, low power, accurate, system with absolute position encoders. We are also looking for systems that can be powered by batteries if possible.

Biggar and Kingston installed and configured ERDAS Imagine version 8.1, and later 8.2, for Solaris. C. Gustafson began evaluating Imagine for its use in our calibration procedures. Biggar and Crowther installed and configured AutoCAD version 12 on our Sun network running under Solaris 2.3. This will be used for designing new instruments and new laboratory apparatus. Biggar installed and tested ethernet, SCSI, and GPIB controllers in the 2 new, rugged field computers. S. Recker began creating a home page for the RSG and connecting pages for faculty to the Optical Sciences Center home page.

Gustafson continued developing the manuals for the Cimel solar radiometer and ASD spectroradiometer. C. Deschappelles and Gustafson determined the Cimel solar radiometer began malfunctioning again because of an internal clock problem. They also collected Reagan and Cimel solar radiometer data concurrently to test the Cimel system. Gustafson and K. Thome were shown by C. Laumann how to set up and operate the solar aureole camera.

Gustafson ordered and received a carrying case for the ASD spectroradiometer, purchased a tripod for the system, and cut the carrying case foam to allow the system to be packed in the case. Gustafson continued evaluating the ASD. She investigated the possibility of replacing the system's fiber optic cable with a longer one to simplify the use of the system for surface reflectance measurements.

K. Thome submitted the SPOT calibration report to CNES for the October 1994 White Sands trip. Gustafson and Thome completed both the Level 0 and Level 1 calibrations of Landsat-5 TM using the October 8 data from White Sands. He continued work on the test data set for the ASTER VNIR/SWIR atmospheric correction. The ATBD for the atmospheric correction was revised. Thome modified the water vapor model code to more closely simulate the geometry of MODTRAN and to allow arbitrary temperature, pressure, and water vapor profiles. He used MODTRAN output to examine which bands between ASTER and MODIS had the smallest differences in band-integrated, top-of-the-atmosphere radiance for a given set of

atmospheric conditions. Recker and Thome made arrangements for the April White Sands trip and the April Lake Tahoe trip. LaMarr calibrated the reflectance panels to be used for the White Sands trip.

E. Nelson and Spyak weighed our truck and mobile laboratory to help determine the proper location of the fuel tanks for the laboratory's generators. Nelson, with some advice from Biggar, coordinated the purchase of generators for the mobile lab. Nelson and Thome took the trailer to the vendor in Phoenix to have the generators installed. Burkhart fabricated parts for the new reflectance yoke in preparation for the March-April White Sands campaign. Nelson, Spyak, and Thome tested the new yoke and Nelson adjusted the system based on this test. We received two polycorders and accessories and two additional Exotech radiometers for use in field measurements. Surface samples from Lunar Lake and Railroad Valley were given to T. Zhao of the OSC Measurement Laboratory to determine their hemispherical, spectral reflectance but no results were obtained because of instrument problems. The samples have since been measured by M. Jacobson.

Sicard spent much of the February acquainting himself with the work of the RSG by reading recent publications. He learned the operation of the 10-channel "Reagan" solar radiometer and how solar radiometer measurements are converted to optical depth. Gustafson showed Sicard the operation of the ASD spectrometer and he investigated the operation of our SWIR spectroradiometer. He designed mounts for both systems which allow them to be aligned to the sun and began learning the IDL software package in preparation for processing and displaying the data. Sicard determined the neutral density filter required to prevent the SWIR spectroradiometer from saturating while viewing the sun. Sicard and Thome travelled to Mt. Lemmon to collect data with the SWIR spectroradiometer and to calibrate the group's other solar radiometers.

Recker performed all administrative tasks associated with the contract.

Anticipated Actions:
Biggar and Slater will attend the CEOS meeting at GSFC on April 30 and May 1, followed by the MCST review on May 2 and the MODIS Science Team meeting from 3-5 May. Biggar will then be attending SIRREX 4 from 8-12 May where he will be making a presentation on the VNIR transfer radiometer. Slater will attend the CEOS/GCOS meeting from 10-12 May. Biggar, Slater, Spyak, and Thome will attend the ASTER Science Team meeting from 22 to 26 May in Flagstaff. Some members of the RSG will attend the MODIS vicarious calibration meeting at Wallops from 7-11 August.

Biggar will verify the VNIR-transfer-radiometer-Optronic-filter measurements by using our germanium detector with the Optronic and also have Jacobson measure the filters with his Cary spectrometer. Biggar will finalize the ASTER cross-calibration results and

prepare a proceedings paper based on the work. He will attempt a calibration of the radiometer using our new NIST lamp. Spyak will continue to design the SWIR transfer radiometer and help design the TIR field radiometer. He will continue efforts to upgrade the blacklab and calibration laboratory facilities. Walker plans to complete the TIR radiometer requirements specifications and begin investigating detectors for the system.

Thome will deliver the atmospheric correction test data set and a revised look-up table to JPL. He will complete all open calibrations and begin examining the Landsat/SPOT cross-calibration issue. Thome will make plans for the April White Sands and Lake Tahoe field experiments. Members of our group will collaborate at Lake Tahoe with ASTER team members from JPL. The purpose of the trip is to attempt to calibrate the ATSR, Landsat TM, and TIMS as well as to develop areas of cooperation between the JPL and UA groups for the calibration and validation of ASTER data. Additional field experiments are being planned for late June at Lunar Lake and Lake Tahoe as rehearsals for SeaWiFS (and MODIS) and for comparisons between AVIRIS and HYDICE.

Brownlee will complete an extension arm for the BRDF camera head, develop a method for measuring the out-of-plane panel BRFs of the reference Spectralon panels for conditions similar to those expected in the field. She will investigate a calibration method for flat-fielding the BRDF meter with the 40-inch spherical integrating source and begin an error analysis for validating the BRDF measurements and perform a field test of the system. The custom filter wheel will be installed in the system. Brownlee will give a presentation her project at NASA's Graduate Student Researchers Program Annual Symposium in Washington, D. C. in May where Crowther will also present a poster on the diffuse-to-global meter.